CLAIMS

1. A method of decryption of an encrypted image having a non-encrypted image intensity pattern $I(x',y')$ and

encoded into a mask having a plurality of mask resolution elements (x_m,y_m) with an encoded phase value $\phi(x_m,y_m)$ and an encoded amplitude value $a(x_m,y_m)$, and

encrypted by addition of an encrypting phase value $\phi_c(x_m,y_m)$ to the encoded phase values $\phi(x_m,y_m)$ and by multiplication of an encrypting amplitude value $a_c(x_m,y_m)$ with the encoded amplitude value $a(x_m,y_m)$,

each mask resolution element (x_m,y_m) modulating the phase and the amplitude of electromagnetic radiation incident upon it with the complex value $a(x_m,y_m)a_c(x_m,y_m)e^{i\phi(xm,ym)+i\phi c(xm,ym)}$, and

the method comprising the steps of

radiating electromagnetic radiation towards the mask,

inserting into the path of the electromagnetic radiation a complex spatial electromagnetic radiation modulator comprising modulator resolution elements (x_d,y_d), each modulator resolution element (x_d,y_d) modulating the phase and the amplitude of electromagnetic radiation incident upon it with a predetermined complex value $a_d(x_d,y_d)e^{i\phi d(xd,yd)}$, the decrypting phase value $\phi_d(x_d,y_d)$ and the decrypting amplitude value $a_d(x_d,y_d)$, respectively, of a modulator resolution element (x_d,y_d) being substantially equal to $-\phi_c(x_m,y_m)$ and $a_c^{-1}(x_m,y_m)$, respectively, of a corresponding mask resolution element (x_m,y_m), and

imaging the mask and the electromagnetic radiation modulator onto the image having the image intensity pattern $I(x',y')$.

2. A method according to claim 1, wherein the step of imaging comprises imaging with a common path interferometer.

3. A method according to claim 1, wherein the step of imaging comprises phase contrast imaging.

4. A method according to claim 2, further comprising the steps of

Fourier or Fresnel transforming electromagnetic radiation modulated by the mask and the complex spatial electromagnetic radiation modulator,

filtering the Fourier or Fresnel transformed electromagnetic radiation by

in a region of spatial frequencies comprising DC in the Fourier or Fresnel plane,

phase shifting with a predetermined phase shift value θ the modulated electromagnetic radiation in relation to the remaining part of the electromagnetic radiation, and

multiplying the amplitude of the modulated electromagnetic radiation with a constant B, and

in a region of remaining spatial frequencies in the Fourier or Fresnel plane, multiplying the amplitude of the modulated electromagnetic radiation with a constant A,

forming the intensity pattern by Fourier or Fresnel transforming, respectively, the phase shifted Fourier or Fresnel transformed modulated electromagnetic radiation, whereby each resolution element (x_m, y_m) of the mask is imaged on a corresponding resolution element (x', y') of the image,

the filtering parameters A, B, θ substantially fulfilling the equation

$$I(x',y') = A^2|a(x',y')e^{i\phi(x',y')} + \overline{\alpha}\,(BA^{-1}e^{i\theta}-1)|^2$$

$\overline{\alpha}$ being the average of the complex phasors $a(x,y)e^{i\phi(x,y)}$.

5. A method according to claim 4, wherein the filtering parameters A and B substantially fulfil that A=1 and B=1, and wherein the absorption of the mask is substantially uniform.

6. A method according to claim 5, wherein the phase shift value θ substantially fulfils the equation

$$|\bar{\alpha}| = \frac{1}{2|\sin\frac{\theta}{2}|}$$

7. A method according to claim 6, wherein the phase shift θ is substantially equal to π.

8. A method according to claim 3, further comprising the steps of

moving the DC-part of the electromagnetic radiation to a second part of the Fourier or Fresnel plane, and

phase shifting the Fourier or Fresnel transformed modulated electromagnetic radiation at the second part of the Fourier or Fresnel plane by θ in relation to the remaining part of the electromagnetic radiation.

9. A method according to claim 8, wherein the step of moving the DC-part of the electromagnetic radiation comprises utilisation of an optical component, such as a grating, a prism, etc, with an appropriate carrier frequency.

10. A method according to claim 3, further comprising the step of phase shifting at selected spatial frequencies constituting a region that is shaped to match the spatial frequency content of the phasors $e^{i\phi(x,y)}$.

11. A method according to claim 3, wherein the step of filtering comprises utilisation of a spatial light modulator.

12. A method according to claim 3, further comprising the step of encoding the optical function of an output lens into the filter.

13. A method according to claim 3, wherein the step of radiating electromagnetic radiation comprises radiation of electromagnetic radiation of different wavelengths corresponding to three different colours, such as red, green and blue, for generation of intensity patterns of arbitrary colours.

14. A method of encryption of an image having an intensity pattern $I(x',y')$ to be decrypted according to claim 1, comprising the steps of

pixellating the intensity pattern $I(x',y')$ in accordance with the disposition of resolution elements (x_m,y_m) of a mask,

encoding the mask with an encoded phase value $\phi(x_m,y_m)$ and an encoded amplitude value $a(x_m,y_m)$, and

encrypting by addition of an encrypting phase value $\phi_c(x_m,y_m)$ to the encoded phase values $\phi(x_m,y_m)$ and by multiplication of an encrypting amplitude value $a_c(x_m,y_m)$ with the encoded amplitude value $a(x_m,y_m)$,

each mask resolution element (x_m,y_m) modulating the phase and the amplitude of electromagnetic radiation incident upon it with the complex value $a(x_m,y_m)a_c(x_m,y_m)e^{i\phi(xm,ym)+i\phi c(xm,ym)}$.

15. A method according to claim 14, further comprising the step of calculating the complex phasor values $a(x,y)e^{i\phi(x,y)}$ of the encoder in accordance with

$$I(x',y') = A^2|a(x',y')e^{i\phi(x',y')} + \bar{\alpha}(BA^{-1}e^{i\theta}-1)|^2$$

for selected phase shift values θ, $\bar{\alpha}$ being the average of the complex phasors $a(x,y)e^{i\phi(x,y)}$,

selecting, for each resolution element, one of two phasor values which represent a particular grey level.

16. A method according to claim 15, wherein the filtering parameters A and B substantially fulfil that A=1 and B=1, and wherein the absorption of the mask is substantially uniform.

17. A method according to claim 16, wherein the step of calculating the phasor values comprises

setting the reconstructed intensity of at least one resolution element (x_0', y_0') of the intensity pattern to zero, and

calculating the phasor values $e^{i\phi(x,y)}$ of the mask in accordance with

$$|\overline{\alpha}| = \frac{1}{2|\sin\frac{\theta}{2}|}$$

$$I(x',y') = 2\left[1 \mp \sin(\phi_{\overline{\alpha}} - \phi(x',y') + \frac{\theta}{2})\right]$$

for selected phase shift values ϕ, $\phi_{\overline{\alpha}}$ being the phase of $\overline{\alpha}$.

18. A method according to claim 17, further comprising the step of selecting the phase shift $\theta = \pi$, selecting $|\overline{\alpha}| = ½$, and calculating the phasor values $e^{i\phi(x,y)}$ of the encoder in accordance with

$$I(x',y') = 2(1-\cos(\phi(x',y')))$$

$$\iint_{encoder} \sin(\phi(x,y)dxdy = 0.$$

19. A method according to claim 14, further comprising the step of encoding the function of an optical component, such as a grating, a prism, etc, with an appropriate carrier frequency, into the mask.

20. A method according to claim 14, further comprising the step of adjusting the modulus of the Fourier transform of the complex phasors $a(x,y)e^{i\phi(x,y)}$ at specific spatial frequencies in order to control the range of intensity levels of the reconstructed intensity pattern.

21. A method according to claim 20, wherein the step of adjusting the modulus of the Fourier transform of the complex phasors $a(x,y)e^{i\phi(x,y)}$ at specific spatial frequencies comprises at least one of the following measures:

a) adjusting the individual complex phasors $a(x,y)e^{i\phi(x,y)}$ of the resolution elements of the mask maintaining prescribed relative intensity levels between intensities of resolution elements of the intensity pattern,

b) adjusting the individual complex phasors $a(x,y)e^{i\phi(x,y)}$ of the resolution elements of the mask by histogram techniques,

c) spatially scaling the complex phasor $a(x,y)e^{i\phi(x,y)}$ pattern of the mask, and

d) utilising half tone coding techniques.

22. A method according to claim 14, wherein each complex phasor $a(x,y)e^{i\Phi(x,y)}$ of the mask is selected from a set of two determined phasors with complementary complex phasor values $a(x,y)e^{i\phi 1(x,y)}$ and $a(x,y)e^{i\phi 2(x,y)}$ in such a way that a specific spatial frequency distribution of the intensity of the electromagnetic radiation in the Fourier or Fresnel plane is attained.

23. A method according to claim 22, wherein the phase $\phi(x,y)$ of complex phasors $a(x,y)e^{i\phi(x,y)}$ of adjacent resolution elements alternates between the two possible complementary complex phasor values $a(x,y)e^{i\phi 1(x,y)}$ and $a(x,y)e^{i\phi 2(x,y)}$.

24. A method according to claim 22, wherein the complex phasors $a(x,y)e^{i\phi 1(x,y)}$ and $a(x,y)e^{i\phi 2(x,y)}$ are complex conjugated.

25. A method according to claim 14, further comprising the step of encoding the optical function of a Fourier-transforming lens into the complex phasors $a(x,y)e^{i\phi(x,y)}$ of the encoder.

26. A method according to claim 14, wherein each of the encrypting phase values $\phi_c(x_m,y_m)$ is substantially equal to a value selected from a set consisting of two phase values.

27. A method according to claims 26, wherein each of the encrypting phase values $\phi_c(x_m,y_m)$ is substantially equal to a value selected from the set consisting of 0 and π.

28. A decryption system for decrypting an encrypted image having a non-encrypted image intensity pattern $I(x',y')$ that has been

encoded into a mask having a plurality of mask resolution elements (x_m,y_m) with an encoded phase value $\phi(x_m,y_m)$ and an encoded amplitude value $a(x_m,y_m)$, and

encrypted by addition of an encrypting phase value $\phi_c(x_m,y_m)$ to the encoded phase values $\phi(x_m,y_m)$ and by multiplication of an encrypting amplitude value $a_c(x_m,y_m)$ with the encoded amplitude value $a(x_m,y_m)$,

each mask resolution element (x_m,y_m) modulating the phase and the amplitude of electromagnetic radiation incident upon it with the complex value $a(x_m,y_m)a_c(x_m,y_m)e^{i\phi(xm,ym)+i\phi c(xm,ym)}$,

the system comprising

a source of electromagnetic radiation for emission of electromagnetic radiation for illumination of the mask,

a complex spatial electromagnetic radiation modulator that is positioned in the path of the electromagnetic radiation and comprising modulator resolution elements (x_d,y_d), each

modulator resolution element (x_d, y_d) modulating the phase and the amplitude of electromagnetic radiation incident upon it with a predetermined complex value $a_d(x_d, y_d)e^{i\phi d(xd,yd)}$, the decrypting phase value $\phi_d(x_d, y_d)$ and the decrypting amplitude value $a_d(x_d, y_d)$, respectively, of a modulator resolution element (x_d, y_d) being substantially equal to $-\phi_c(x_m, y_m)$ and $a_c^{-1}(x_m, y_m)$, respectively, of a corresponding mask resolution element (x_m, y_m), and

an imaging system for imaging the mask and the electromagnetic radiation modulator onto the image having the image intensity pattern $I(x', y')$.

29. A system according to claim 28, wherein the imaging system comprises a common path interferometer.

30. A system according to claim 28, wherein the imaging system comprises a phase contrast imaging system.

31. A system according to claim 29, further comprising

means for Fourier or Fresnel transforming the electromagnetic radiation modulated by the mask and the complex spatial electromagnetic radiation modulator and being positioned on a propagation axis of the modulated radiation,

a spatial filter for filtering the Fourier or Fresnel transformed electromagnetic radiation by

in a region of spatial frequencies comprising DC in the Fourier or Fresnel plane,

phase shifting with a predetermined phase shift value θ the modulated electromagnetic radiation in relation to the remaining part of the electromagnetic radiation, and

multiplying the amplitude of the modulated electromagnetic radiation with a constant B, and

in a region of remaining spatial frequencies in the Fourier or Fresnel plane, multiplying the amplitude of the modulated electromagnetic radiation with a constant A,

means for forming the intensity pattern by Fourier or Fresnel transforming, respectively, the phase shifted Fourier or Fresnel transformed modulated electromagnetic radiation, whereby each resolution element (x_m, y_m) of the mask is imaged on a corresponding resolution element (x', y') of the image,

the filtering parameters A, B, θ substantially fulfilling the equation

$$I(x',y') = A^2|a(x',y')e^{i\phi(x',y')} + \overline{\alpha}\,(BA^{-1}e^{i\theta}-1)|^2$$

for selected phase shift values θ, $\overline{\alpha}$ being the average of the complex phasors $a(x,y)e^{i\phi(x,y)}$.

32. A system according to claim 31, wherein the filtering parameters A and B substantially fulfil that A=1 and B=1, and for each (x,y) of the encoder: a(x,y)=1.

33. A system according to claim 32, wherein the phase shift value θ substantially fulfils the equation

$$|\overline{\alpha}| = \frac{1}{2|\sin\frac{\theta}{2}|}$$

34. A system according to claim 33, wherein the phase shift θ is substantially equal to π.

35. A system according to claim 30, further comprising

means for moving the region of spatial frequencies comprising DC to a second part of the Fourier or Fresnel plane, and wherein

the spatial filter is adapted to phase shift the transformed modulated electromagnetic radiation at the second part of the Fourier or Fresnel plane by θ in relation to the remaining part of the electromagnetic radiation.

36. A system according to claim 35, wherein the means for moving the region of spatial frequencies comprising DC to a second part of the Fourier or Fresnel plane comprises an optical component, such as a grating, a prism, etc, with an appropriate carrier frequency.

37. A system according to claim 31, wherein the spatial filter comprises a spatial light modulator.

38. A system according to claim 31, wherein the spatial filter is adapted to perform the optical function of an output lens by appropriate encoding of the spatial filter.

39. A system according to claim 28, wherein the source of electromagnetic radiation is adapted to radiate electromagnetic radiation of different wavelengths corresponding to three different colours, such as red, green and blue, for generation of intensity patterns of arbitrary colours.

40. A system according to claim 31, further comprising a first and a second Fourier transforming lens, the mask being positioned in the front focal plane of the first lens, the spatial filter being positioned at the back focal plane of the first lens, and the second lens being positioned so that its front focal plane is positioned at the position of the back focal plane of the first lens.

41. A system according to claim 31, further comprising one Fourier transforming lens, the spatial filter being positioned at the back focal plane of the lens.

42. A system according to claim 31, further comprising one imaging lens, the spatial filter being positioned in the back focal plane of the lens.

43. A system according to claim 31, further comprising a polarising beam splitter and a quarter wave plate and/or a phase filter reflecting electromagnetic radiation incident upon it.

44. A system according to claim 31, wherein the spatial filter changes the phase of the radiation in the region of spatial frequencies comprising DC and leaves the phase of the remaining part of the radiation unchanged.

45. A system according to claim 31, wherein the spatial filter do not change the phase of the radiation in the region of spatial frequencies comprising DC and changes the phase of the remaining part of the radiation.

46. A system according to claim 31, wherein the spatial filter blocks the radiation at the region of spatial frequencies comprising DC and leaves the remaining part of the radiation unchanged.

47. A system according to claim 31, wherein the source of electromagnetic radiation is a Laser.

48. A system according to claim 28, wherein each of the encrypting phase values $\phi_c(x_m, y_m)$ is substantially equal to a value selected from a set consisting of two phase values.

49. A method according to claims 48, wherein each of the encrypting phase values $\phi_c(x_m, y_m)$ is substantially equal to a value selected from the set consisting of 0 and π.